newsletter

December 2008

Happy Holidays and a Happy New Year!

Welcome to the Utah Department of Transportation (UDOT) Research Division Newsletter. The newsletter is a quarterly publication that provides current information on the Division's research activities.

Our goal in Research is to be at the forefront of innovation, and we will be using this newsletter to bring you information on what's new and progressive in transportation. We will also share with you what UDOT is researching and how we are implementing new technologies.

Wishing all of you a happy holiday season and a peaceful and prosperous 2009.

Sincerely,
The UDOT Research Team

In This Issue: (click on desired article, click on logo at top to return to this page)

By: Michael Fazio
UDOT Research Division

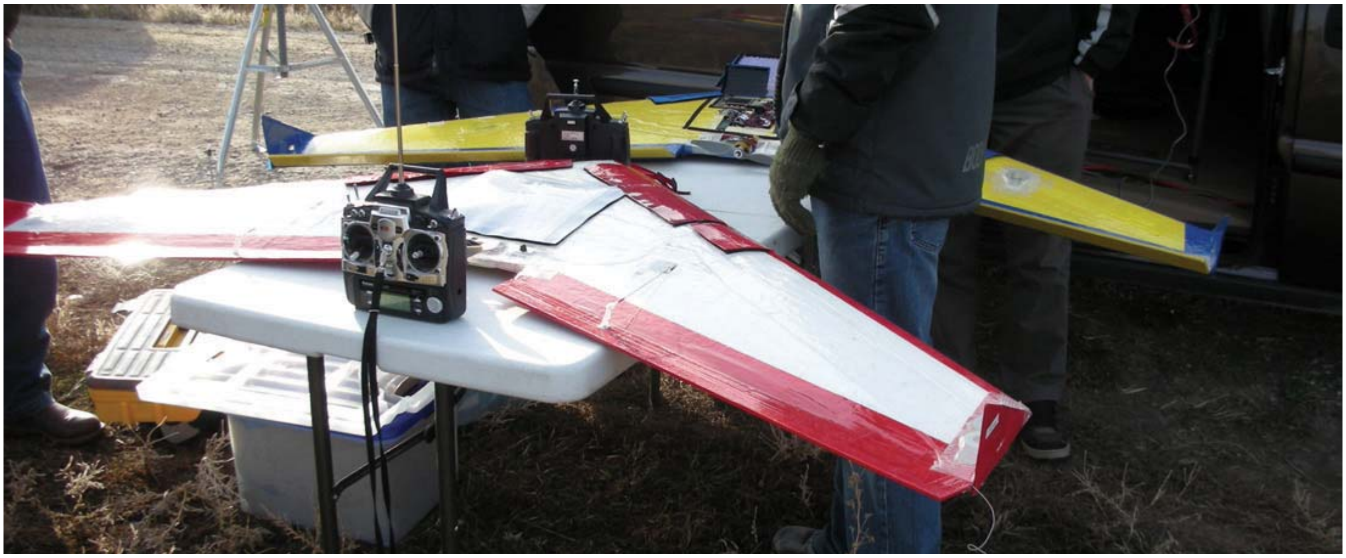
"IF WE KNEW WHAT IT WAS WE WERE DOING, IT WOULD NOT BE CALLED RESEARCH, WOULD IT?"

Research is about ideas. Research is also about finding out what works and what doesn't.

A couple of months ago I was visiting with a professor who had a sign in his office quoting Albert Einstein: "If we knew what it was we were doing, it wouldn't be called research, would it?" Our mission in Research is to find out so you won't have to. We scour for ideas, we test them and then we let you know if they work.

We are getting ideas from many sources. Last month we witnessed a demo of a remote controlled model plane that takes aerial pictures. USU Research Center modified an open source program to geo-reference the plane and the pictures. Digital cameras are mounted on the plane, which flies on a predetermined course at low altitude (100 to 200 meters) taking ground pictures. A GPS system guides the plane, which lands by itself at predetermined locations. The high definition pictures provide geo-referenced details of ground features. The rather inexpensive application could be useful for assessing the condition of our roads and also be a design tool.

We have many ideas (we currently have more than sixty active research projects) but we need more. We hope you'll join us at our annual workshop, UTRAC on April 7, to give us ideas and help us select those ideas to research. For more information, please contact Michael Fazio at mfazio@utah.gov.



USU Research Center used radio controlled aircraft with digital cameras to take ground photos.

By: Blaine Leonard
UDOT Research Division

RESEARCH PROJECTS MOVE FORWARD -- BOTH NEW AND OLD

Based on the results of the UTRAC Workshop held last spring, the UDOT Research Division has initiated nine new research projects.

The nine new research projects were selected by groups of UDOT engineers, consultants, and university researchers from a set of over 50 proposed research efforts during the workshop. The projects cover a broad range of needs in the Department, and have such diverse titles as "Failure of Surface Courses Beneath Pavement Markings", "Developing Flood Frequency Relationships for Small Watersheds in Utah", "Automated Delay Estimates for Traffic Signals", and "Comparison of Steel and GFRP Reinforced Lightweight Precast Bridge Deck Panels". The complete list of new projects can be found on the Research web site under the 2008 UTRAC Workshop heading.

With these new projects underway, it is time to start planning for the next UTRAC Workshop. The workshop will be held on April 7, 2009 at the Salt Lake Community College Larry Miller conference center in Sandy. The Division will be soliciting problem statements for this next workshop beginning in late December. Problem Statements will be due in mid March.

The new projects initiated this year will require about $350,000 during fiscal year 2009. Much of this funding comes from the federal "State Planning and Research" (SPR) funds, which are a small, mandated percentage of federal highway funds. These SPR funds also support our participation in NCHRP projects, pooled fund projects, and other nationwide research efforts. State dollars match the federal funds, and also

fund other projects and programs within the Research Division.

Many research projects span multiple years. Including the nine new projects just initiated, the Research Division is currently managing 68 projects with a total contract value of $4.6 million. Since a variety of studies show that a dollar spent in research yields between 7 and 11 dollars of ultimate value, this money is well spent and forms the basis for some of the important innovations and improvements throughout UDOT.

By: Blaine Leonard
UDOT Research Division

2008 UTRAC Conference

While a few of the research projects are performed entirely in-house, most of the research efforts, about 85 percent of the projects, are produced by faculty and graduate students at the University of Utah, Utah State University, and Brigham Young University. Our relationship with these engineering faculty are a key to our success, as their insights, knowledge, and resources seek solutions to some of our greatest challenges. An annual report of research activities outlines all of the research, implementation, and technology transfer activities of the Research Division. The latest version of this report will be available in early January and will be posted on the web site.

Each year, the Research Division concludes a number of research studies. Some of the recent projects brought to a completion are "Crashes in the vicinity of major crossroads", "Sensitivity of Half-Cell Potential Measurements to Properties of Concrete Bridge Decks", and "Analysis of the Hamburg Wheel Tracking Device to Predict Behavior of Asphalt Mixtures at Different Temperatures". These varied titles indicate the broad variety of research undertaken by the Research Division. Reports detailing the results of these studies can be found on the Research Division web site.

New research, on-going research, and completed research. The efforts of the Research Division move forward, seeking new ideas, new solutions, and new innovations for UDOT and the transportation community at large. For more information about any of these efforts, contact any of the members of the Research Division.❑

By: Barry Sharp
UDOT Research Divisioin

NEW LIGHT WEIGHT URETHANE GROUT FOR PIPE LINERS INSTALLATION

Pipe culverts, more than ever require relining as a repair remedy that is far less costly than to remove and replace old, failing pipe culverts.

Historically sand-cement grout, weighing about 140 pounds per cubic foot, has been the most popular product to fill voids between the old existing pipe and the new pipe liner that may be smooth bore high density polyethylene or poly vinyl plastic pipe.

Matt Parker, Region 3 Resident Engineer managed a culvert renewal project just west of Santaquin, Utah on SR-6, MP 155 +/-. Several culverts were lined and a new type of grout was introduced on this project.

Modular Construction, Inc. from Orem, Utah contracted to grout the voids in the lined culverts with a mixture of urethane, water, cement and fly-ash. This product has a weight of about 50 pounds per cubic foot and reaches a compressive strength of 500 pounds per square inch (psi). A special grout pump was used to pump the light-weight grout into the existing voids in the culvert relining process. The light -weight product pumps at a lower pressure rate that the traditional sand cement grout pumps. The urethane grout more nearly addresses the filling with high predictability than the traditional grouting process.

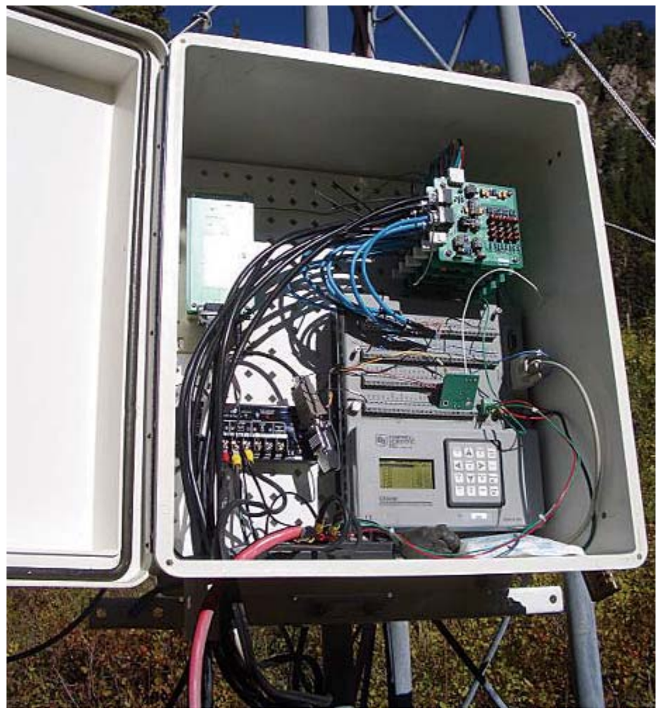
The cost of the light-weight grout is about $150 per cubic yard and the sand-cement grout is

$100 per cubic yard. The light-weight grout pumps more grout than the traditional sand-cement grout to potentially net out at equal total price.

If interested in the new type of light-weight grout contact Barry Sharp of the UDOT Research Division at 801 965 4314, rsharp@utah.gov or Mr. Wendall Miller of the Modular Construction Inc, 204 East 860 South, Suite E, Orem, Utah 85058, phone: 801.434.8700....❑

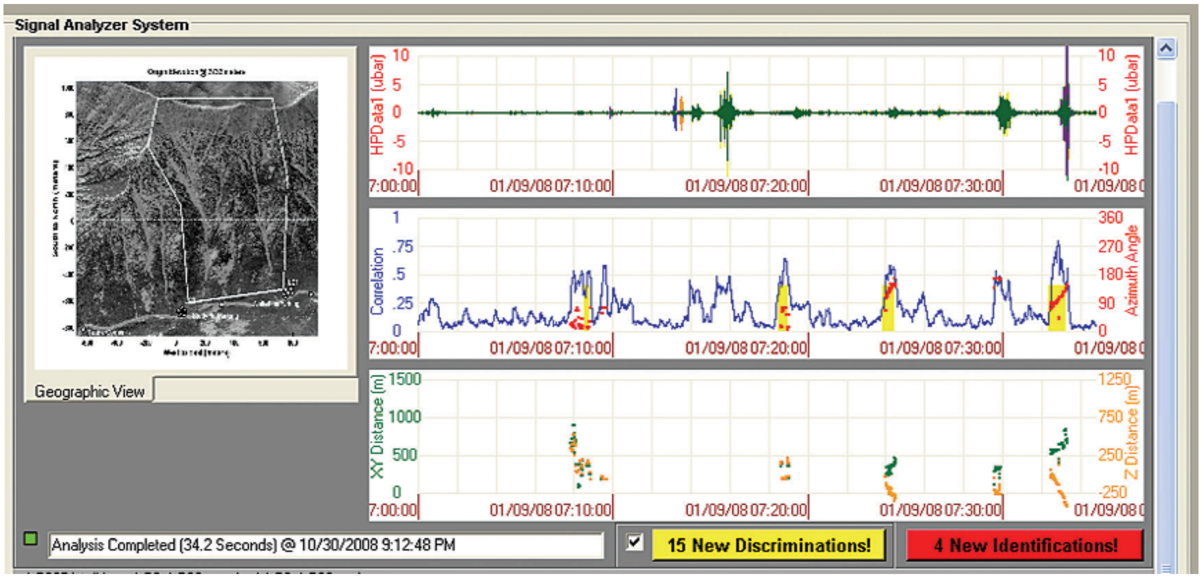
By: Maria Vyas & Abdul Wakil
Senior Transportation Planner, Fehr & Peers and UDOT Research Division

INFRASOUND AVALANCHE MONITORING SYSTEM

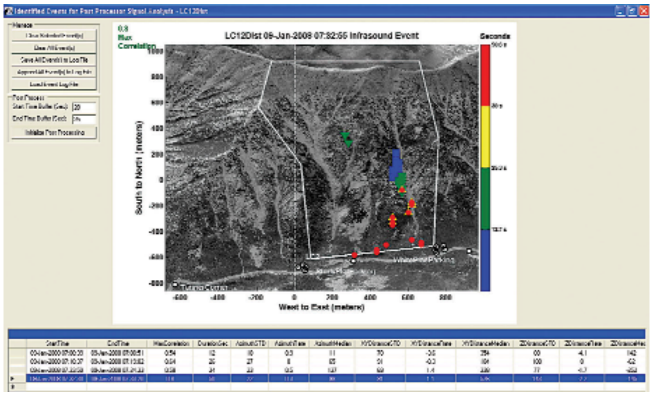


Little Cottonwood Canyon Road, or SR-210, connects the Salt Lake Valley with the Town of Alta, Alta Ski Lifts, and Snowbird Ski Resort at the top of Little Cottonwood Canyon. Little Cottonwood Canyon Road has one of the highest risks for avalanche activity for almost any road in North America. SR-210 is threatened by 35 major avalanche paths, and the White Pine, White Pine Chutes, and Little Pine avalanche paths are some of the most active paths in the canyon. Currently, avalanche control is accomplished through road closure and artillery control, occasionally supplemented by helicopter control. UDOT's avalanche forecasters in Little Cottonwood Canyon have some of the most technologically advanced equipment available, but they still face difficulties in the canyons. For instance, inclement weather or low visibility, provide great challenges in order to determine visually whether avalanche activity is occurring naturally or whether control efforts have been successful. To combat this problem, UDOT Region Two installed an Infrasonic Avalanche Detection system in 2006. The system was installed with the help of Intermountain Labs (IML), to monitor White Pine, White Pine Chutes, and Little Pine avalanche paths.

Early research showed that snow avalanches generate acoustic signals within a low noise band of the sub-audible infrasonic frequency spectrum (Bedard and Greene 1988, Bedard 1989, Bedard 1994). Low frequency infrasound signals have the ability to propagate miles from the avalanche source and provide a basis for developing automated monitoring systems that can operate in locations unaffected by avalanche activity. Reliable implementation of infrasound avalanche monitoring technology requires innovative solutions to problematic ambient wind noise and interfering signals(Robert F. Kubichek, Jerry C. Hamann, John W. Pierre). The Infrasonic Avalanche Detection System provides remote sensing of avalanche activity to allow Little Cottonwood Canyon forecasters to monitor avalanche risks when visibility is poor. In 2008, UDOT undertook a research evaluation to determine whether the Infrasonic provided reliable early warning of natural avalanche cycles and confirmed avalanche control operations; whether it reduced UDOT's costs; and what improvements to the system are needed. The research is still in progress. This research evaluation is being conducted by Mr. Jon Nepstad and Maria Vyas of the Fehr & Peers group.



Little Cottonwood Canyon's Infrasonic system has three separate infrasound monitoring arrays, each of which has six sensors. The infrasound sensors sit on wooden pallets, and are attached to a series of cables extending outward from each sensor. The sensors are powered by solar panels and transmit data via cables to a central datalogger at the array, which in turn transmits the data to UDOT's Lower Guard station via wireless radio link. At Lower Guard, a central processing unit (CPU) compiles the data which is then presented through a user interface. The Infrasonic system operates in near real-time, providing information in 90-second intervals on a continual basis. The CPU at Lower Guard processes the data from the arrays to determine which of the transmitted signals represent avalanche activity. If infrasound signal events were detected, the CPU will classify each detected signal event as either an "identified" avalanche event or as a "discriminated" non-avalanche, or interference, event. The CPU classifies each event into either an "identified" bin or a "discriminated" bin, which are then represented to the user as red or yellow command buttons, respectively. The user can then inspect the signal events assigned to either of the two bins by clicking on the appropriate command button.



In addition, the Infrasonic system currently provides remote notification of avalanche events to IML via text-messaging to a cell phone. However, none of the avalanche forecasters currently receive remote notification, nor would cell phone text message be the most appropriate method of communication in Little Cottonwood Canyon, where several locations lack cell phone service due to the steep and enclosing canyon walls. Instead, radio notification of the Infrasonic system avalanche identifications would be useful, as it could be broadcast to all forecasters simultaneously. This research evaluation is still in progress and will be completed in a near future. The Technical Advisory Committee members for this research evaluation are: Ms. Shana Lindsey, Mr. Ralph Patterson, Mr. Liam Fitzgerald, Mr. Jon Nepstad, Ms. Maria Vyas, and

Mr. Abdul Wakil. For more information about this research, please contact Maria at M.Vyas@fehrandpeers.com or Abdul at awakil@utah.gov..❑

By: Dr. Pedro Romero
Ph.D., P.E., Department of Civil & Environmental Engineering, University of Utah

SELECTING THE RIGHT TEMPERATURES TO DETERMINE MOISTURE SUSCEPTIBILITY OF ASPHALT MIXTURES USING THE HAMBURG WHEEL TRACKING DEVICE

The Hamburg Wheel Tracking Device (HWTD) is used as part of the Utah Department of Transportation (UDOT) specifications to evaluate the performance of hot mix asphalt (HMA) for rutting and moisture susceptibility. The UDOT's Materials Manual of Instruction, Part 8, Section 990.04.02 specifies that the test temperature shall be 50 ºC without any considerations to the type of material being tested or the location where the mixture will be placed. Work performed by the University of Utah has shown that this one temperature is not enough to capture the potential performance of mixtures prepared with modified binders used in hot climates.

Background

The HWTD was developed in Hamburg, Germany in the 1970's, and has been used by many state agencies, UDOT, as a way to test an asphalt mixture's susceptibility to rutting and moisture damage. The test starts by placing two asphalt slabs, which are prepared to be representative of paving asphalt, in a high temperature water bath. While submerged, one steel wheel for each slab is tracked back and forth over the surface and the depth of the wheel imprint is measured at each pass and stored electronically. This is shown in Figures 1 and 2. As the wheel imprint increases, the rut depth increases at a constant rate. If moisture damage is present, a typically flat creep line becomes a steep line of stripping. The point at which the tangents of these two lines inter-

Figure 1: Hamburg Wheel Tracking Device showing two slabs being tested

Figure 2: Slab showing large rut after being testing in the Hamburg WTD. (Note that while there is a large rut, there is minimum aggregate stripping)

sect is known as the stripping inflection point. This point describes the number of passes an asphalt sample can withstand at a given temperature before the rock and binder begin to separate (or strip) from each other. If a slab withstands 20,000 passes without stripping and has less than 10 mm of rutting, the mixture is considered adequate.

Figure 3 shows a schematic of the results from a slab tested in the HWTD. The test results show initial compaction at the start, an inflection point around 7,800 passes, and a final rut depth in excess of 15 mm.

Current testing protocols are based on work done in the early 1990's prior to the adoption of the binder Performance Grade (PG) system and the increased use of modified binders; thus new guidelines were needed. UDOT's Research Division along with UDOT Materials recognized the need to improve test protocols to capture the effect of different temperature environments on the behavior of high performance modified binders.

Innovation

The University of Utah Bituminous Materials Laboratory took the challenge of evaluating the effect of test temperature on the results from the HWTD and its prediction of potential mixture behavior. Other factors such as air voids variability and effect of acid modification were also studied.

A single aggregate source and a single aggregate gradation were used. A dense-graded aggregate gradation, shown in figure 4, was mixed with a binder content of 4.7% by total mass of the mixture. The aggregate was obtained from a pit source in central Utah. This aggregate was selected because it is a soft limestone with a known history of stripping, thus representing a "worst case scenario".

Two asphalt binder sources were used as a way of comparing and confirming results between typical binder grades. The base PG 58-28 asphalt binders were modified by the suppliers to obtain a PG 70-28. The PG 70-28 and the base PG 58-28 were blended to obtain a PG 64-28 according to UDOT specifications. This created 3 binder grades from two different sources.

Each combination of asphalt binder and aggregate was tested in the HWTD at different temperatures to determine how the behavior of the mixture changed with increased test temperature.

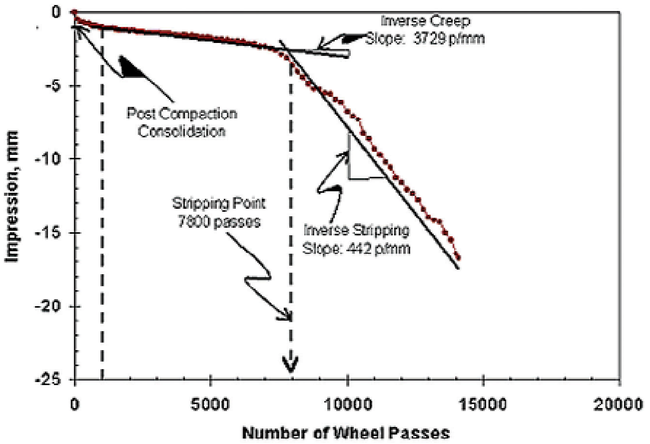


Figure 3: Schematic of the Hamburg WTD Test Results

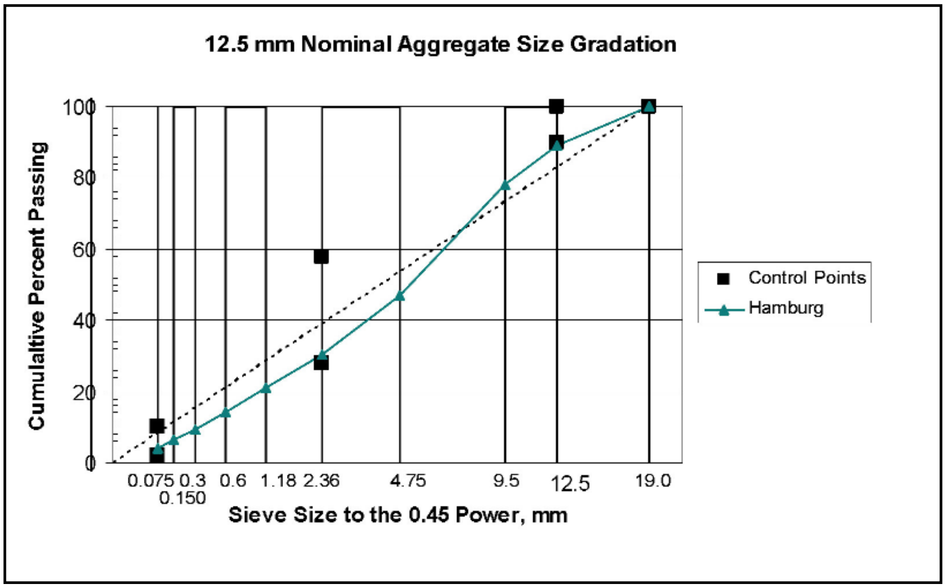


Figure 4:

Aggregate gradation used in the study

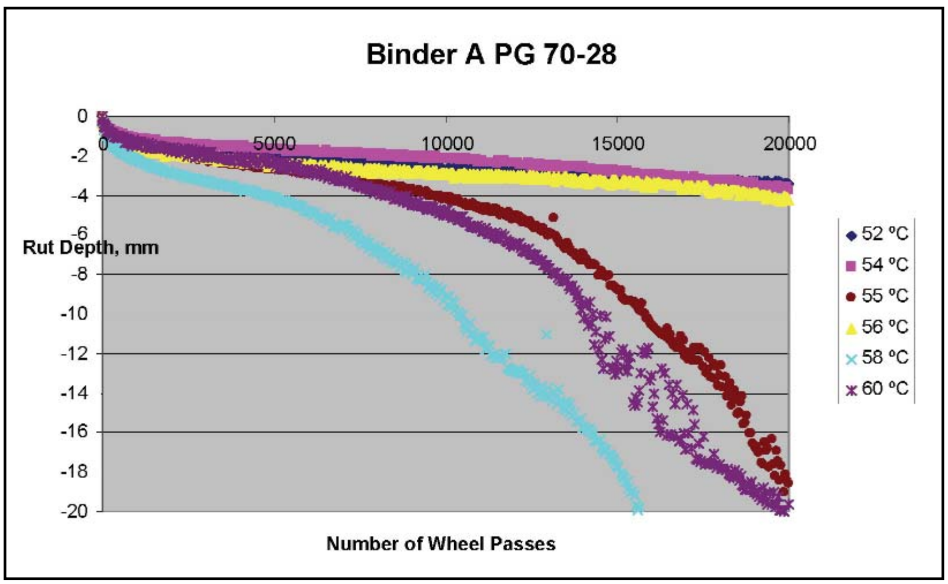


Figure 5:

Test results for a PG 70-28 at different temperatures

Results

As expected, the results indicate that asphalt mixtures performed better, in terms of both resistance to rutting and stripping, as the temperature decreased. However, as shown in Figure 5, there is not a monotonic change in post-failure performance as the temperature changes. Instead, two distinct behaviors are observed, one in which the material shows no signs of moisture damage and another in which the material shows significant moisture damage. Such difference in behavior is attributed to a critical temperature that causes the material to change. Below this critical temperature the material responds by deforming based on its structural stability but shows no stripping. Above this temperature, the material changes and the asphalt is stripped from the aggregate; the material literally disintegrates showing catastrophic failure. The critical temperature for stripping was referred to as the Critical Stripping Temperature (CST). The CST values obtained from testing are shown in Table 1.

Table 1: Critical stripping temperature from HWTD Test Results

Performance Grade Based on UDOT Specs	Critical Stripping Temperature. ºC	
	Binder A	Binder B
70 -28	55 (PG - 15*)	54 (PG - 16)
64 -28	54 (PG - 10)	49 (PG - 15)
58 -28	49 (PG - 9)	<45 (PG - 14)

*The number in parenthesis represents the difference between the UDOT High Temperature PG and the CST

Table 2: Recommended test temperature in the HWTD for different binder grades

Binder High Temperature Performance Grade Based on UDOT Specs	Recommended Test Temperature ºC
58	46
64	50
70	54

It was determined that below the CST, the hydrostatic stresses caused by the wheel forcing the water into the mix are not always enough to break the bond and displace the asphalt binder from the aggregate, thus one can incorrectly conclude that a mixture is not susceptible to moisture damage when in fact it is. This is particularly critical in locations where the pavement temperature reaches values where a PG70 or other high performance modified binder is used.

Furthermore, stripping is a catastrophic failure mode resulting from the material undergoing compositional changes. Thus, after stripping, the rut depth has no physical meaning since it represents the behavior of a different material than the one originally prepared. Only a mixture that does not strip can be evaluated based on its rut depth while a mixture that strips simply fails and should be rejected.

Conclusions

Based on the data collected, it was recommended that standard protocols be revised and new HWTD tests at higher and lower temperatures be adopted to ensure that future HMA projects do not contain aggregate-binder combinations that are susceptible to both rutting and moisture damage. The new temperatures are shown in Table 2 and are based on the environment for which the mix is intended, regardless of the actual binder grade used. A mixture intended for a "hot" location should be tested at a higher temperature than a mixture intended for a "cold" location regardless of the binder grade used.

Benefits

By having a standard test that can eliminate potentially poor performing asphalt mixtures, UDOT can better serve the public by building long lasting roads.

For more information please contact Dr. Pedro Romero at romero@civil.utah.edu...............................❑

By: Reuel S. Alder P.E.
UDOT Engineering Services

CMGC AT UDOT

CMGC or Construction Manager General Contractor is a modified Design Build process in which the owner holds the contract for both the consultant designer and the contractor.

CMGC puts the owner in charge of project decisions and keeps the cost savings with the owner. The chief benefits of this process are speed of delivery and flexibility.

Comparing CMGC projects to Traditional projects shows timesavings in four primary areas. CMGC is able to begin the project earlier, the design takes less time, the construction takes less time and overlapping design and construction reduces project time.

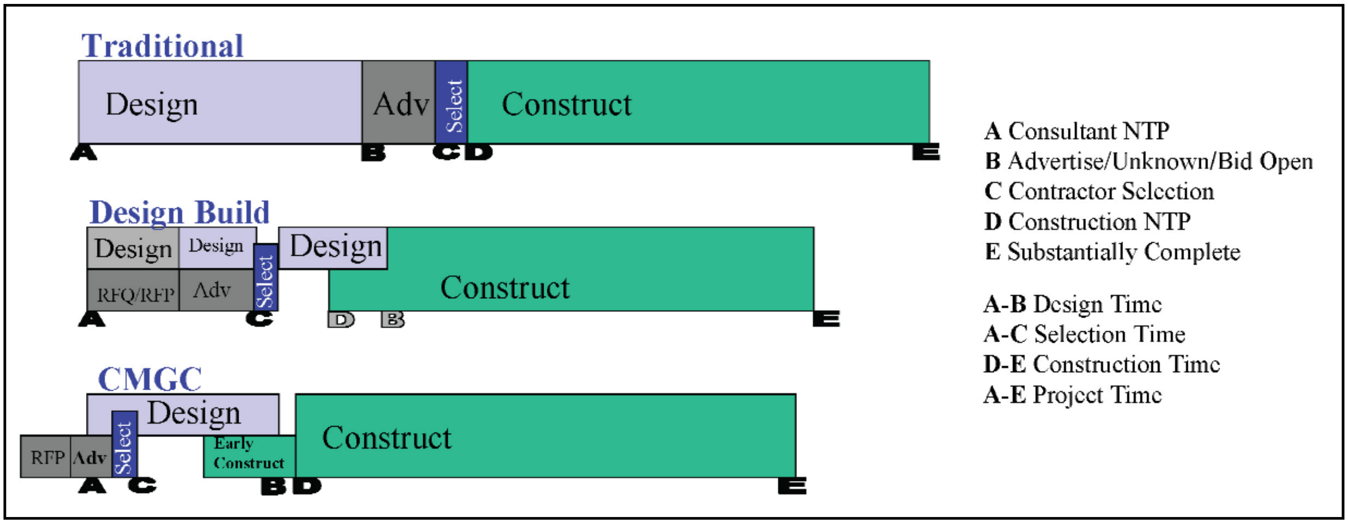
We are able to begin the project earlier because we do not need a design to advertise and the selection process is simpler. A typical RFP for a Design Build process is over 500 pages and averages 250 days. A typical RFP for CMGC is 30 pages and can be shorted to less than 100 days. It is possible to start the RFP development during the environmental process and reduce the selection time to about 70 days. Many projects have been able to save a construction season because they could get started early. This reduced time to contract can save a year in inflation costs.

Some projects report a cost savings of 40% in design cost for a 25% or more reduction in time. This savings is attributed to the improved communication that occurs between the contractor and the designer in the design process. The contractor helps to select constructible solutions that save the designer time in analyzing alternatives. This communication also reduces the level of detail required for traditional design packages. In addition design flaws or deficiencies, are discovered through a continuous peer review process that reduces total design effort.

Involving the contractor in design reduces risk and improves constructability. Contractors are encouraged to identify, track, and eliminate risk. If there is something unknown the project manager will task the contractor to investigate and resolve the risk or at least be better prepared to meet a risk that has become an event.

The designer is also able to tailor the design to the contractor's capabilities and the contractor has time during the design process to better plan his approach to construction and remove design options that effect constructability. Utility risks in particular are minimized because the contractor is on board to schedule utility work and create a more effective construction sequencing and schedule. Some project managers see a 20% savings in construction time.

Project time is not only shortened by reduced design time and construction time but also by the overlapping of construction and design. Projects are able to order long lead items to reduce or eliminate wait time. In addition early demolition work, utility work, site preparation, mobilization, etc, can occur before full construction begins. This represents another 20% savings in project duration and when combined with other savings may result in a 30% timesaving to the overall project time. When innovation is added to the process a



dramatic reduction in public impact is also achieved. The 4500 South bridge replacement over I-215 reduced the time impact on the public from months to days.

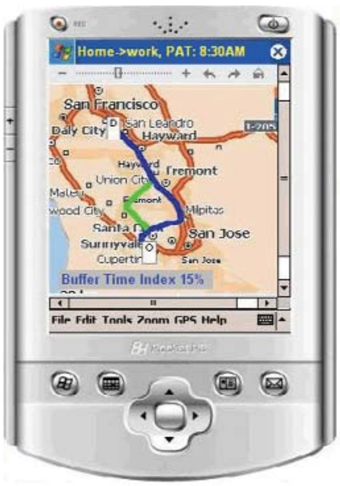
Flexibility is another key ingredient. In any project we are always concerned about cost, schedule, and quality. We want cost and schedule minimized and quality maximized but when we focus on one of these concerns we compromise the other two. There will be a first, second, and third priority weather we admit it or not. Quality includes our impact on the public and our responsiveness to their needs as well as the characteristics of the roadway and structures. If we put a high priority on quality and hold to a tight schedule then cost will rise. CMGC gives us a delivery method that provides flexibility in responding to the priorities of cost, schedule, and quality.

CMGC was chosen as the delivery method for Riverdale road over Design Build because of the need for speed and to manage risk. CMGC gave us the flexibility to deal with risk in real time. Not everything had to be known before we began. In addition the contractor was able to meet the public early and become committed to the public's needs, the project goals, and the design. The contractor was able to adjust the construction approach because he was not tethered to a hard bid price. In a traditional approach the contractor will resist any change the public needs that is not captured in the initial proposal.

When a project is hard bid we loose flexibility. We have to know the public's expectations and capture them in the design and RFP before the project is bid. Any errors in our understanding of the public needs or any changes to those needs can and will affect cost. In a hard bid contract the contractor has a production schedule to meet to stay on schedule and stay profitable. CMGC enables flexibility because we do not have to know everything going into the project and we can change our approach to accommodate the public. We know this flexibility has a cost but we balance the cost against quality and public satisfaction. In doing this we avoid costly change orders. Riverdale had 5% change orders as opposed to 12% change orders on traditional projects. In addition almost all of these change orders were anticipated and planed for.

If we want the absolute lowest price we must capture absolutely the public needs in our design and approach to the project. If all risks are known and understood and all public concerns are known and understood then the traditional approach will provide the lowest cost; however, CMGC can also be executed in a traditional mode and provide the best cost. But if risk cannot be reduced or eliminated and we are constructing in a publicly sensitive location CMGC is the best approach because it provides us the flexibility to respond to uncertainty. We can delay our decisions until we have the best information possible. For more information regarding CMGC, please contact Reuel at ralder@utah.gov or Robert Stewart rstewart@utah.gov.

By: Dr. Xuesong Zhou
Department of Civil and Environmental Engineering,
University of Utah

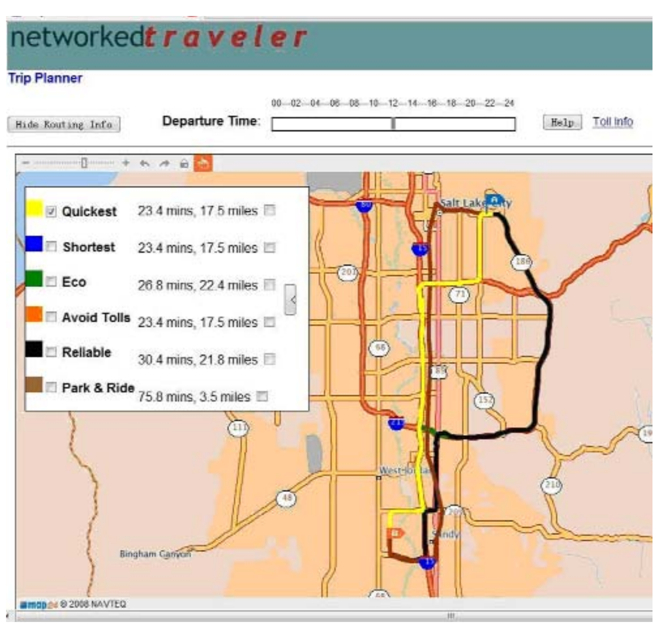


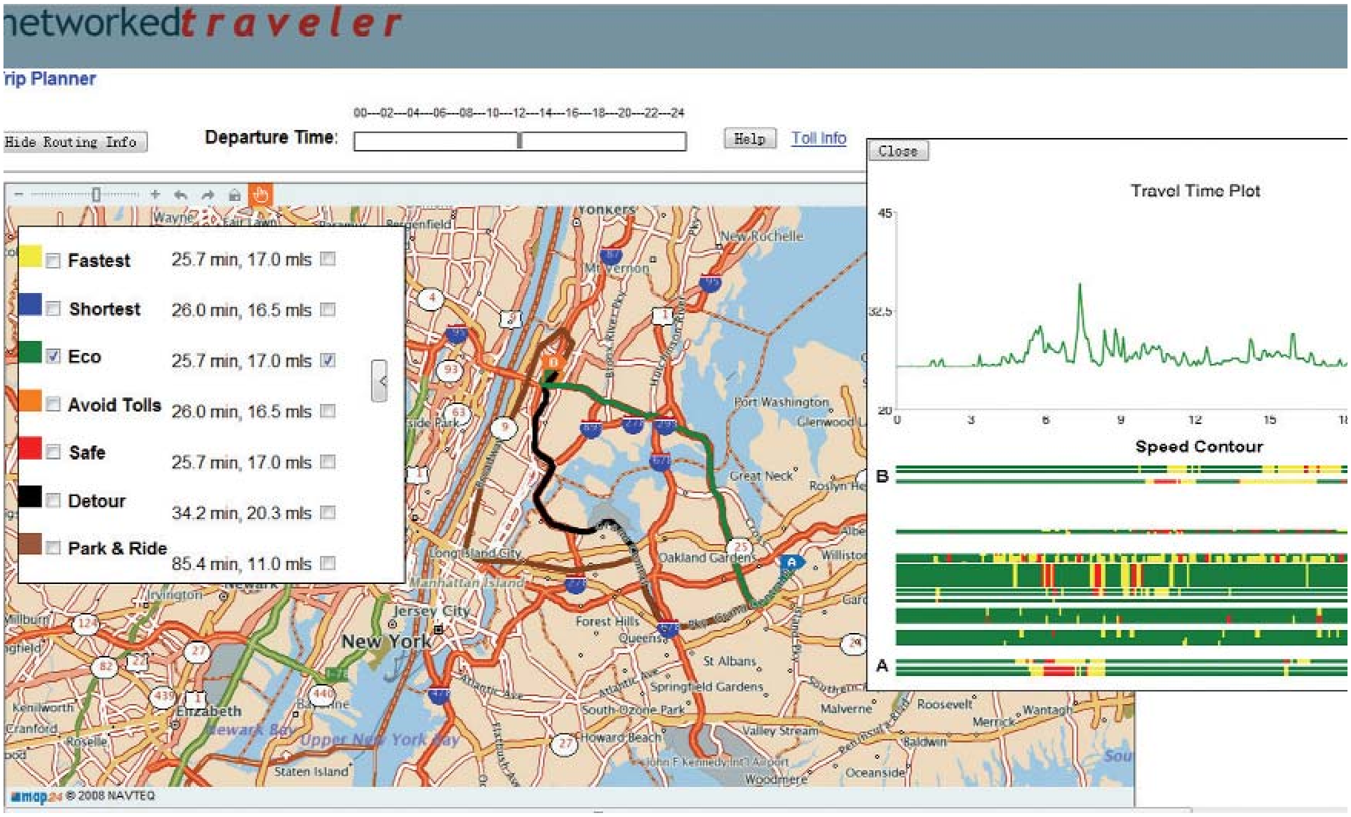
Connected Travelers with Better Information

University of Utah Researchers are Prototyping Next-Generation Trip Planning Tools for Commuters to Make Smart Decisions.

SafeTrip-21 is a new initiative sponsored by the U.S. Department of Transportation's (USDOT) Research and Innovative Technology Administration (RITA), and it builds upon research into the use of electronic information, navigation, and communications technologies to prevent accidents and alleviate congestion by providing drivers with real-time safety warnings, traffic and transit information, and advanced navigational tools.

Working together with UC Berkeley, California *Partners for Advanced Transit and Highways* (PATH), and NAVTEQ research teams, assistant professor Dr. Xuesong Zhou and his team at the University of Utah developed an Internet-based dynamic routing system delivered on a consumer handheld device, such as a cell phone. The system aims to provide travelers with alternative routes that can avoid traffic jams and reduce com-





muting delays. Based on the Map24 interactive map platform provided by NAVTEQ, the screen shots show a web page and a mobile phone interface with multiple alternative routes in Salt Lake City and the San Francisco Bay Area, respectively, the best of which will be, in large part, dependent on real-time traffic information.

In the 15th ITS World Congress at New York, November 16-20, 2008, the University of Utah team worked with California PATH and other SafeTrip-21 partners to successfully demonstrate how ITS technologies can improve safety and enhance the travel experience using readily available wireless communications devices. The on-going research goal is to provide travelers with a personalized menu of real-time traffic and transit information services, so that they can make smart departure time, mode, and route decisions - wherever they are in their journeys. In 2009, the University of Utah research team will file test their multi-modal and multi-criteria trip planning system in a number of metropolitan areas.

For more information regarding this technology, please contact Dr. Xuesong Zhou at zhou@eng.utah.edu

By: Dr. Mitsuru Saito, Ph.D., P.E., and Thomas G. Jin
Department of Civil & Environmental Engineering, Brigham Young University

EVALUATING THE ACCURACY LEVEL OF TRUCK TRAFFIC DATA ON STATE HIGHWAYS

As Dr. Saito and his research assistant worked on the development of user cost estimation procedures for work zones a couple of years ago, they realized that UDOT's truck traffic data might not be as accurate as they wished.

Truck traffic significantly alters the amount of user costs incurred by delays caused by work zones. Truck traffic plays an important role in many aspects of UDOT's daily activities, including transportation planning, highway operational analysis, and pavement and bridge designs. At the planning level, monitoring movements of trucks on the state highway system will help UDOT properly allocate their highway funds. At the operational level, truck traffic is essential for evaluating the capacity and level of service of transportation facilities; and at design level, truck traffic is a main factor for designing pavement structure and super and substructures of bridges. Therefore, it is essential that UDOT has a clear idea about the level of accuracy of their truck traffic data. With this background this study on truck traffic data accuracy was started. The final report of this study will be available by the end of February 2009.

In this article major findings are reported. Out of the existing 73 automatic traffic recorder (ATR) locations that classify vehicles by length and by FHWA's 13 vehicle classification types, 30 stations were randomly selected for the study, including 28 locations with length classification and 2 locations with FHWA vehicle classification. One-hour video recording of traffic was done at each ATR location and the same location was repeated a couple of weeks later using a VHS video camera (see Figure 1). The

Figure 1. Field data collection

Figure 2. Data reduction

Table 1. The 13 FHWA Vehicle Classes

Class	Description	Class	Description
1	Motorcycles	8	4 or fewer axle combination trucks
2	Passenger cars	9	5-axle combination trucks
3	Other 2-axle, 4-tire single-unit vehicles	10	6+ axle combination trucks
4	Buses	11	5-axle multi-trailer trucks
5	2-axle, 6-tire single-unit trucks	12	6-axle multi-trailer trucks
6	3-axle, 6-tire single-unit trucks	13	7+ axle multi-trailer trucks
7	4+ axle single-unit trucks		

Table 2. Vehicle Reclassification

FHWA's 13 Classes	UDOT's Length-Based Classification
Class 1 and Class 2	16 ft (0 ft to 16 ft)
Class 3	30 ft (17 ft to 30 ft)
Class 4 through Class 8	50 ft (31 ft - 50 ft)
Class 9 through Class 12	79 ft (51 ft - 79 ft)
Class 13	> 79 ft

video recording was converted to an AVI file to analyze the traffic using a software program that allows the analyst to classify vehicles frame by frame (see Figure 2). The classification counts from the video film were considered as "ground truth" data for comparison.

As the traffic data were reduced, vehicles were first classified using FHWA's 13 vehicle classifications shown in Table 1. In order to compare with UDOT's length based vehicle classification, vehicles were reclassified following the regrouping rule shown in Table 2.

The analysis results showed that the current FHWA 13 vehicle-classification ATRs (two of them were examined in this study) were not producing accurate truck count data and excluded from further analyses. Using the data from the 28 length-classification ATRs, in-depth statistical analyses were done. There was one extreme outlier ATR station, and this station was excluded also. Hence, vehicle count data from 27 ATR stations were used. Because two data sets were taken at each station, 54 data sets were available for further analyses.

Table 3 shows average error rate for each length group together with variance, standard deviation (SD) and upper boundary of the 95th percentile confidence interval (UB of CI) and lower boundary of the 95th percentile confidence interval (LB of CI). The error rate is computed as (ATR counts - Ground truth)/(Ground truth). For instance, the average error rate of the total count is 0.0012, meaning only 0.12% differences from the ground truth count, which is very good. When a confidence interval contains "zero" within the interval, the error rate is considered as zero, meaning two average values are statistically equivalent. For instance the confidence interval of the error rate for the total count is

As shown in Table 3, the 16-foot and 50-foot length groups were clearly undercounted. The 30-foot and greater-than-79-foot length groups were over counted. The 30-foot length group was especially unreliable. Two potential reasons are considered for this outcome. One potential reason is that the ATR's algorithm has difficulty in distinguishing vehicles in this length group.

Table 3. Results of Statistical Analysis of Length Type of Data (Error Rate)

Length Group	16 Feet	30 Feet	50 Feet	79 Feet	> 79 Feet	Total
Average	-0.2004	20.1244	-0.4332	-0.0304	1.8509	0.0012
Variance	0.0472	416.9507	0.0251	0.0889	22.4007	0.0051
S D	0.2173	20.4194	0.1583	0.2982	4.7329	0.0717
UB of CI	-0.1434	25.4726	-0.3917	0.0477	3.0905	0.0200
LB of CI	-0.2573	14.7763	-0.4747	-0.1085	0.6113	-0.0176

Table 4. Results of Statistical Analysis of Regrouped Length Type of Data (Error Rate)

Length Group	16ft and 30ft	Trucks (Over 30ft)	Total
Average	0.0573	-0.2113	0.0012
Variance	0.0097	0.0279	0.0051
S D	0.0983	0.1672	0.0717
UB of CI	0.0831	-0.1675	0.0200
LB of CI	0.0316	-0.2551	-0.0176

Another potential reason is that the length of vehicles in this range is difficult to distinguish by video analysis as well, hence resulting in large difference in this length group.

The 79-foot length group and the total count contains zero within the confidence interval; hence, for these length groups, ATR counts and ground truth counts were statistically equivalent. What this tells is that the vehicle counts from these two count groups are very reliable.

Because of the large differences in each length group, vehicles were regrouped into only two groups: the 16-foot and 30-foot groups combined and the trucks (over 30-feet long). Table 4 shows the results of this comparison. The 16-foot and 30-foot combined group had average error rate of 0.0573 (5.73%) and the 95th percentile confidence interval of 0.0316 to 0.0831, containing no zero within the confidence interval, which indicated that this group had 5.73% over-counting. As for the truck group, the average error rate was -0.2113 (21.13%) and the 95th percentile confidence interval was -0.2551 to -0.1675, containing no zero within the confidence interval, which meant that the truck group had 21.13% under-counting.

In summary, the study concluded that trucks were undercounted at the sampled ATR locations. It was recommended that UDOT request the vendors of ATRs to improve their vehicle classification algorithms. While waiting for improved algorithms to be developed, it was also recommended that UDOT develop a procedure to adjust these undercounted truck counts by synthesizing other truck related data such as Weight-In-Motion (WIM) data and commodity flow data. Another approach may include a methodology to use the truck counts from relatively accurate ATR locations to adjust the truck counts of the ATR locations with lower accuracy levels. For questions, please contact Dr. Saito at msaito@et.byu.edu or Mr. David Stevens at davidstevens@utah.gov... ❑

By: Ken Berg
UDOT Research Division

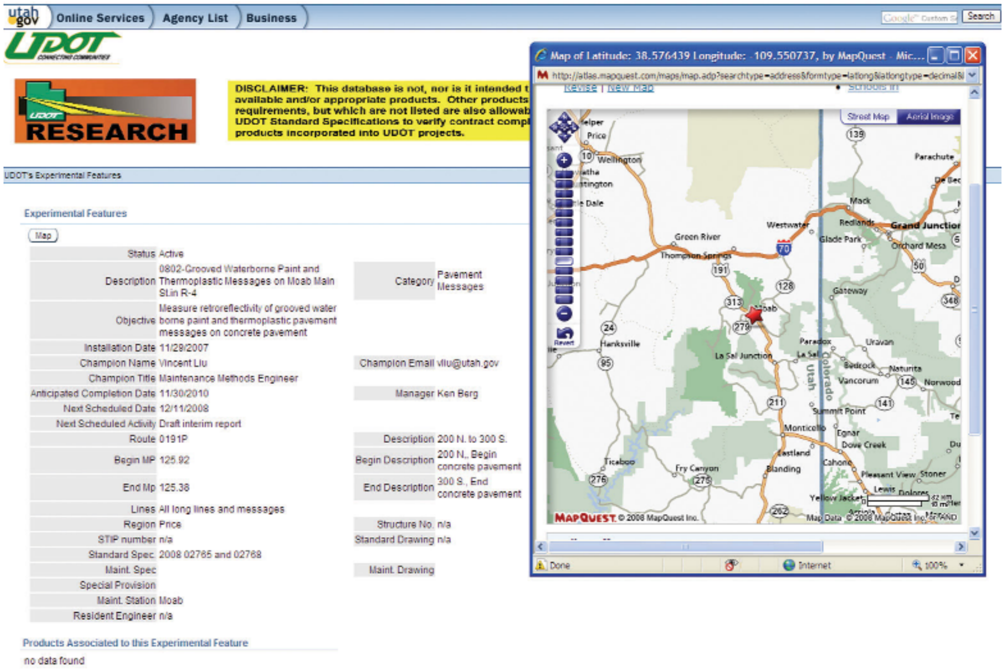
PRODUCT EVALUATION WEB SITE COMING SOON

UDOT's new product and experimental feature processes have, in the past, been managed in two separate desktop database applications. Any information sharing with customers required printed or emailed reports which, inherently, created a time lag. In an effort to provide consolidated, real-time product evaluation information to its customers, the Research Division has sponsored the development of the UDOT Product Evaluation web site.

The main page has links for searching the New Product Catalogue and the Experimental Features databases. It also includes a disclaimer which is intended to emphasize that the list is not a comprehensive list of all possible products that could be included in projects, and that UDOT specifications should be referred to for product acceptance criteria. The disclaimer shows on all the pages.

The New Product Catalogue lists products that are considered by the New Product Evaluation Panel (NPEP) to be of potential use to the Department. It is searchable and sortable by trade name, manufacturer and category. Product information also includes reference to national testing standards, if applicable. Clicking on each record will give more details and any NPEP comments about the product.

Active and completed experimental features are searchable by region, description, and category. Other information shown includes objective, next scheduled activity and date and project completion date. Each feature will also be mapped in MapQuest. Work plans, reports and other documents can also be attached to each feature.



There is also the ability to cross-link the records in each data base. One experimental feature can be linked to multiple product records, and one product record can be linked to multiple experimental feature records.

The web site is currently still being tested. Release date is expected to be Jan. 2009.

Contact Ken Berg kenberg@utah.gov for more information....................❑

MR. LEONARD GOES TO WASHINGTON...

UDOT Research Program Manager, Blaine Leonard elected President of the American Society of Civil Engineers (ASCE), headquartered in Reston, Virginia

Well, not quite the same way that Mr. Smith (Jimmy Stewart) did. Blaine Leonard, the Research Program Manager here at UDOT, is the President-elect of the American Society of Civil Engineers (ASCE), which is headquartered in Reston, Virginia, just outside of Washington, D.C. Blaine will spend a year as President-elect, and then become ASCE President for the following year. Serving in ASCE is a volunteer position, and Blaine will retain his duties here at UDOT, managing research projects, working on the annual UTRAC Workshop, coordinating research efforts, and other related duties. His ASCE duties, however, will require him to travel frequently, as he attends Board and committee meetings, speaks at ASCE Sections and Branches around the country, and participates in technical conferences. About his dual role, Blaine has said "This is a unique opportunity to serve the profession, and I am looking forward to the experience. I appreciate the support of everyone at UDOT, at all levels, who have made this possible and allowed me the time to take on this role."

Blaine was inaugurated as President-elect at the ASCE Annual Meeting in Pittsburgh in early November. He will serve as a member of the ASCE Board of Direction, and then become the Board Chair when he becomes President next year. He also currently serves as the Chair of a committee which is looking at the future of civil engineering, known as the Vision 2025 committee. This group is seeking to raise the stature and role of civil engineers around the world to meet the new challenges of infrastructure renewal, increased natural and manmade risks, emerging technology, and globalization.

ASCE was founded in 1852, and currently has 146,000 members worldwide. Blaine is the first President-elect to ever come from Utah, and is the first in many years to serve ASCE while actively employed by a government agency. He says he is honored to fill this role, and to represent Utah and UDOT in this way. As President-elect, and then President, Blaine will have many opportunities to advocate for infrastructure spending, innovative design and construction, and enhanced research and implementation, and will be able to cite many UDOT examples in his efforts. He will also have the chance to interact with engineering students throughout the nation and outline for them the many opportunities on the horizon for civil engineers. We wish him luck in this new responsibility....................❑

Mr. David Stevens

NEW RESEARCH TEAM MEMBER

An ongoing feature of our quarterly newsletter is an introduction to one of our Research and Development Division staff members. In this edition, we will introduce you to Mr. David Stevens.

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David began working for the Research Division in November 2008. He is helping with preparations for the next UTRAC workshop and currently manages the following research projects relating to planning, materials, construction, and traffic operations and safety for the Research Division:

- Extracting Vehicle Classification from TOC Video
- Structural Condition Index of Flexible Pavement
- Evaluating The Level of Accuracy of Truck Traffic Data on State Highways
- Materials Characterization for the AASHTO 2002 Pavement Design Guide
- Cold Temperatures and Fatigue Quality Control Test for Asphalt Mixes
- HMA Temperature Placement Limitations
- Development of a Decision Support Tool for Assessing Vulnerability of Transportation Networks

Mr. Stevens is originally from the Logan, Utah area. He received a bachelor's degree in civil engineering from Utah State University and a master's degree in civil/geotechnical engineering from the University of California at Davis. For the past several years David has worked as a geotechnical engineer for a national geo-environmental firm in Sacramento, California and Salt Lake City on various types of projects including buildings, pipelines, flood-control levees, bridges, highways, airports, and other facilities.

David and his wife have three young children. His hobbies include walking, hiking, camping, gardening, cooking, spending time with his family, and learning about earthquake risk in Utah.

We are very pleased to have David as a member of our Research Team. We congratulate David and wish him luck in his new job. You can contact Mr. Stevens at davidstevens@utah.gov..❑

You Know You Need To Contact Research When...

- You would like to learn more about how a new product performs on the road.
- You have a brilliant idea and/or product and would like a team of brilliant dedicated people to research it.
- You are introduced to a promising technology and do not have time and funding to test it.
- You require any technology transfer information or any experimental feature tested.
- You have a problem to be researched and solved.
- You require diligent inquiry about a subject matter and an analysis of scientific data.

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Completed UDOT Research

Research publications are valuable resources, documenting the results of important research projects. For a list of recently completed Research Projects, please visit the Research & Development website at: www2.udot.utah.gov/index.php?m=c&tid=235. If you would like to obtain an electronic copy or a printed copy of our completed research, please contact awakil@utah.gov.

Need a Literature Search?

The UDOT Research Division and Lester Wire Library provide an important service through literature searches. These searches help identify published information about a topic of interest. To request a search, provide a brief description and some key words and submit it to awakil@utah.gov. Or you can submit your request online at http://www.udot.utah.gov/index.php/m=c/tid=895/

Please send your comments and questions about this Newsletter to Abdul Wakil awakil@utah.gov or (801) 964-4455